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Sir:

Transmitted herewith for filing is the patent application of

Named Inventor(s) and

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For:

FOCUS ADJUSTMENT APPARATUS, CONTROL METHOD THEREFOR, AND
MEDIUM FOR SUPPLYING CONTROL PROGRAM THEREFOR

Enclosed are:

☒ 41 page(s) of specification, 1 page(s) of Abstract, 8 Page(s) of claims☒ 21 sheets of drawing ☒ formal ☐ informal☐ — Page(s) of Declaration and Power of Attorney☐ Unsigned☐ Newly Executed☐ Copy from prior application☐ Deletion of inventors including Signed Statement under 37 C.F.R. § 1.63(d)(2)☒ Incorporation by Reference: The entire disclosure of the priority application(s) identified below, is considered as being part of the disclosure of the accompanying application and is incorporated herein by reference.☐ Microfiche Computer Program (Appendix)☐ — page(s) of Sequence Listing☐ computer readable disk containing Sequence Listing☐ Statement under 37 C.F.R. § 1.821(f) that computer and paper copies of the Sequence Listing are the same☒ Claim for Priority Japanese Application No 11-245272 filed 8/31/99 and 2000-239115 filed 8/7/00☐ Certified copy of Priority Document(s)

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- ☐ English translation documents
- ☐ Information Disclosure Statement
- ☐ Copy of 1 Cited reference
- ☐ Copy of PTO-1449 filed in parent application serial No. _____.
- ☐ Preliminary Amendment
- ☒ Return receipt postcard (MPEP 503)
- ☐ Assignment Papers (assignment cover sheet and assignment documents)
- ☐ A check in the amount of \$40.00 for recording the Assignment.
- ☐ Assignment papers filed in parent application Serial No. _____.
- ☐ Certification of chain of title pursuant to 37 C.F.R. § 3.73(b).
- ☐ This is a ☐ continuation ☐ divisional ☐ continuation-in-part (C-I-P) of prior application serial no. _____.
- ☐ Cancel in this application original claims _____ of the parent application before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)
- ☐ A preliminary Amendment is enclosed. (Claims added by this Amendment have been properly numbered consecutively beginning with the number following the highest numbered original claim in the prior application.
- ☐ The status of the parent application is as follows:
- ☐ A Petition For Extension of Time and a Fee therefor has been or is being filed in the parent application to extend the term for action in the parent application until _____.
- ☐ A copy of the Petition for Extension of Time in the co-pending parent application is attached.
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- ☐ Please abandon the parent application at a time while the parent application is pending or at a time when the petition for extension of time in that application is granted and while this application is pending has been granted a filing date, so as to make this application co-pending.
- ☐ Transfer the drawing(s) from the patent application to this application.
- ☐ Amend the specification by inserting before the first line the sentence:
This is a ☐ continuation ☐ divisional ☐ continuation-in-part of co-pending application Serial No. _____ filed _____.

I. CALCULATION OF APPLICATION FEE (For Other Than A Small Entity)

	Number Filed		Number Extra	Rate	Basic Fee
					\$ 690.00
Total Claims	39	-20=	19	x\$18.00	\$ 342.00
Independent Claims	3	- 3=	0	x78.00	\$ 0
Multiple Dependent Claims					
	[] yes				Additional Fee =
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Total: \$1,032.00

- [] A statement claiming small entity status is attached or has been filed in the above-identified parent application and its benefit under 37 C.F.R. § 1.28(a) is hereby claimed. Reduced fees under 37 C.F.R. § 1.9(F) (50% of total) paid herewith \$ _____.
- [X] A check in the amount of \$1,032.00 for payment of the application filing fees is attached.
- [] Charge Fee(s) to Deposit Account No. 13-4500. Order No. _____. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.
- [X] The Assistant Commissioner is hereby authorized to charge any additional fees which may be required for filing this application, or credit any overpayment to Deposit Account No. 13-4500, Order No. 1232-4641. A DUPLICATE COPY OF THIS SHEET IS ATTACHED.

Respectfully submitted

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Applicants : Seiya OHTA
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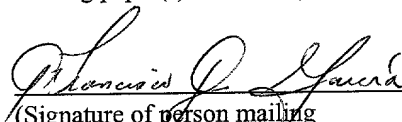
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I hereby certify that the following attached paper(s) and/or fee
Application Fee Transmittal (in duplicate); 41 pp. of specs., 1 page of abstract, 8 pp. claims (39 TOTAL
claims); 21 Sheets of Formal Drawings (Figs. 1-21); Check in the amount of \$1,032.00; and return receipt
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is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37
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TITLE OF THE INVENTION

FOCUS ADJUSTMENT APPARATUS, CONTROL METHOD THEREFOR,
AND MEDIUM FOR SUPPLYING CONTROL PROGRAM THEREFOR

5 FIELD OF THE INVENTION

The present invention relates to a focus
adjustment apparatus for an image sensing apparatus
such as a digital camera or video camera, a control
method therefor, and a medium for supplying the control
10 program therefor.

BACKGROUND OF THE INVENTION

Conventionally, as the automatic focusing
function (to be referred to as the AF function
15 hereinafter) of a camera, a hill-climbing scheme has
been proposed by, e.g., Japanese Patent Laid-Open
No. 62-103616 and known. In recent years, as image
sensing apparatuses used for video cameras, 3-CCD type
apparatuses used by broadcasting stations or for
20 operational use have been widely used. Accordingly,
the image quality increasingly improves, and the
focusing accuracy is also rapidly increasing. This
tendency is expected to be strong in the future.

For lenses as well, along with intensive
25 competition for values added and discriminations, the
magnification becomes high, and the AF accuracy of a

are interchangeable. Abundant accessories including an extender or tube attached between the camera and the lens to convert the magnification or change the optical characteristics are also important as products. A lens
5 portion including such an accessory attached to the lens is called a lens system. The accessory largely influences the chromatic aberration in the lens system.

Hence, for the conventional AF control, a high focus accuracy is required for a high image quality,
10 while AF at the best focus position cannot be obtained because the chromatic aberration is enlarged due to the high magnification.

SUMMARY OF THE INVENTION

15 It is an object of the present invention to provide an apparatus such as a focus adjustment apparatus capable of appropriately adjusting focusing with respect to chromatic aberration, a control method therefor, and a medium for supplying the control
20 program therefor.

In order to achieve the above object, according to the present invention, there is provided an apparatus such as a focus adjustment apparatus comprising a color component signal forming circuit for
25 forming a plurality of color component signals corresponding to predetermined different color

description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a functional block diagram showing an image sensing apparatus according to the first embodiment of the present invention;

10 Figs. 2A-1 to 2C-3 are graphs showing signal characteristics so as to explain the process of setting the mixing ratio of video signals in accordance with chromatic aberration information, in which Figs. 2A-1 to 2A-3 are graphs showing lens chromatic aberrations in the wide-angle state, middle state, and telephoto state, respectively, Figs. 2B-1 to 2B-3 are graphs showing AF signal characteristics in the wide-angle state, middle state, and telephoto state, respectively, when the video signal mixing ratio is uniform, and Figs. 2C-1 to 2C-3 are graphs showing AF signal characteristics in the wide-angle state, middle state, and telephoto state, respectively, when the video signal mixing ratio changes;

Fig. 3 is a graph showing the mixing ratio based on the lens chromatic aberration;

25 Fig. 4 is a flow chart showing the control processing procedure of the first embodiment;

Fig. 5 is a functional block diagram showing an image sensing apparatus according to the second embodiment of the present invention;

5 Figs. 6A-1 to 6C-3 are graphs showing signal characteristics when the F-number is F1.8 so as to explain the process of setting the mixing ratio of video signals in accordance with chromatic aberration information, in which Figs. 6A-1 to 6A-3 are graphs showing lens chromatic aberrations in the wide-angle
10 state, middle state, and telephoto state, respectively, Figs. 6B-1 to 6B-3 are graphs showing AF signal outputs in the wide-angle state, middle state, and telephoto state, respectively, when the video signal mixing ratio is uniform, and Figs. 6C-1 to 6C-3 are graphs showing
15 AF signal characteristics in the wide-angle state, middle state, and telephoto state, respectively, when the AF signal mixing ratio changes;

Figs. 7D-1 to 7E-3 are graphs showing signal characteristics when the F-number is F16 so as to
20 explain the process of setting the mixing ratio of video signals in accordance with chromatic aberration information, in which Figs. 7D-1 to 7D-3 are graphs showing lens chromatic aberrations in the wide-angle state, middle state, and telephoto state, respectively,
25 and Figs. 7E-1 to 7E-3 are graphs showing AF signal characteristics in the wide-angle state, middle state,

and telephoto state, respectively, when the video
signal mixing ratio is uniform;

Fig. 8 is a graph showing the mixing ratio based
on the lens chromatic aberration and F-number;

5 Fig. 9 is a flow chart showing the control
processing procedure of the second embodiment;

Fig. 10 is a functional block diagram showing an
image sensing apparatus according to the third
embodiment of the present invention;

10 Fig. 11 is a flow chart showing the control
processing procedure of the third embodiment;

Fig. 12 is a flow chart showing the control
processing procedure of the fourth embodiment;

15 Fig. 13 is a flow chart showing the control
processing procedure of the fifth embodiment;

Fig. 14 is a functional block diagram showing an
image sensing apparatus according to the sixth
embodiment of the present invention;

20 Fig. 15 shows graphs of signal characteristics so
as to explain the process of setting the mixing ratio
of video signals in accordance with chromatic
aberration information;

Fig. 16 is a graph showing the mixing ratio based
on the lens chromatic aberration;

25 Fig. 17 is a flow chart showing the control
processing procedure of the sixth embodiment;

Fig. 18 is a functional block diagram showing an image sensing apparatus according to the seventh embodiment of the present invention;

Fig. 19 is a flow chart showing the control
5 processing procedure of the seventh embodiment;

Fig. 20 is a functional block diagram showing an image sensing apparatus according to the eighth embodiment of the present invention; and

Fig. 21 is a flow chart showing the control
10 processing procedure of the eighth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention will be described below with reference to the
15 accompanying drawings.

(First Embodiment)

Fig. 1 is a block diagram showing the first embodiment of the present invention. Referring to Fig. 1, reference numeral 1 denotes an optical system
20 comprising a rear focus zoom lens (RFZ lens) having four lens groups. The RFZ lens 1 comprises a first lens group (front element) 101 as a fixed lens group, a second lens group (variator) 102 as a movable lens group having a variable magnification function, a third
25 lens group (afocal) 103 as a fixed lens group, and a fourth lens group (RR) 104 as a movable lens group

having a focusing function and a function as a compensator for correcting an imaging plane variation due to the variable magnification. Each lens group is actually constructed by a plurality of lenses, though
5 the number of lenses of each lens group is not particularly limited.

The image of a light beam from an object is formed on a photoelectric conversion element as an image sensing means such as a CCD. The photoelectric
10 conversion element comprises image sensing elements 2-1, 2-2, and 2-3 which are located on the monochromatic light emerging surface sides of prisms 21-1, 21-2, and 21-3 as color separation means, respectively. A blue
- (B) component of the three primary colors is reflected
15 by the blue reflecting dichroic film of the prism 21-3 and forms an image on the image sensing element 2-3. A red (R) component is reflected by the red reflecting dichroic film of the prism 21-1 and forms an image on the image sensing element 2-1. A green (G) component
20 is transmitted through the prisms 21-1, 21-2, and 21-3 and forms an image on the image sensing element 2-2.

An aperture member 3 adjusts the amount of light incident on an photoelectric conversion element 2. An aperture driving unit 4 drives the aperture member 3
25 under the control of a control circuit 7 such that a predetermined amount of light is incident on the

photoelectric conversion element 2. Reference numeral 5 denotes an aperture position detector. An aperture detection circuit 6 detects the output from the aperture position detector 5 and outputs the signal to the control circuit 7. A lens position detector 22 detects the positions of the second lens group 102 and fourth lens group 104. A lens detection circuit 23 detects the output from the lens position detector 22 and outputs the signal to the control circuit 7.

10 Lens driving units 8 and 9 such as stepping motors drive the movable lens groups 102 and 104, respectively. Drivers 10 and 11 drive the driving units 8 and 9, respectively.

15 An amplifier 12 amplifies the output from the photoelectric conversion element 2. A process circuit 13 has a focus signal generation circuit 14 (to be referred to as an AF signal generation circuit 14 hereinafter) for converting a signal as an image sensing signal into a signal such as an NTSC video

20 signal and mixing R, G, and B video outputs at an arbitrary ratio to generate a focus signal (to be referred to as an AF signal hereinafter) for the AF function. A chromatic aberration information storage section 15 constituted by a ROM or the like stores

25 chromatic aberration information of each lens in advance. An AF section 16 constituted by a

information storage section 15 and AF section 16 are included in the control circuit 7. As the AF scheme, the hill-climbing scheme has been proposed and known and a detailed description thereof will be omitted.

In the AF operation, the R, G, and B components do not always form images at the best focus position on the same imaging plane because of the chromatic aberrations of lenses and the positions of the image sensing elements 2-1, 2-2, and 2-3.

For a zoom lens, generally, the aberration is small in the wide-angle state, though the aberration becomes large in the telephoto state. In the wide-angle state, optimum AF can be performed using a signal generated from all the R, G, and B video signal components. However, in the telephoto state, the AF operation may not sufficiently function due to the aberration.

In the present invention, the chromatic aberration (MTF) of each lens is prepared as information in advance. In accordance with the chromatic aberration information, the focus position is

set mainly in consideration of the G component having the highest visual sensitivity in the video signal, thereby making defocusing due to the chromatic aberration unnoticeable. In addition, all pieces of information of the R, G, and B components are used as much as possible, and the mixing ratio of the R, G, and B video signals is changed in generating an AF signal so as to prevent the focus position in an object containing only the R or B component from becoming undetectable, thereby always detecting the best peak position without any defocusing.

Fig. 2A-1 shows the shift amounts between the R, G, and B components on the imaging plane due to chromatic aberrations in the wide-angle state. In this case, the shifts between the R, G, and B components are small. Hence, as shown in Fig. 2B-1, even when the ratio of the R, G, and B components of the AF signal is 1 : 1 : 1, only one peak position is obviously present. However, since the R, G, and B components do not completely match, the gradient of the output peak of the AF signal is almost flat, and the actual peak position can hardly be detected by the AF operation. As shown in Fig. 2C-1, when the mixing ratio of the R, G, and B components is set to $G : B : R = 1 : 0.9 : 0.8$, the peak can easily be detected. Detailed examples of numerical values of the R, G, and B mixing ratio to be

described below are merely examples for a descriptive convenience and are not limited to those values.

Fig. 2A-2 shows a state wherein the R, G, and B components do not form images at the best peak position on the same plane and are separated from each other due to the chromatic aberrations in the middle region. As shown in Fig. 2B-2, if the R, G, and B mixing ratio is $G : R : B = 1 : 1 : 1$, two peaks as AF signals are present at two points: a point near the G and B components and a point corresponding to the R component, and the AF operation may stop at one of the peak positions. Generally, a video signal contains the G component at a high ratio, so the G peak position is close to the best focus position for the human eye. Hence, the more the position where the AF operation stops is separated from the G component, the larger the defocus state becomes.

As shown in Fig. 2C-2, when the mixing ratio of the R, G, and B components is set to $G : B : R = 1 : 1 : 0.3$, the peaks can converge to one point, so the focus position can be detected on the basis of the signal component which is contained in the video signal at a high ratio. When the signal component ratio in the video signal is known in advance, it can be determined which color component signal is to be used as a major component for AF signal generation.

Fig. 2A-3 shows a state wherein no best peak position is obtained on one imaging plane because of the chromatic aberrations in the telephoto region. AF signal peaks based on the R, G, and B video signal components are present on different imaging planes. As shown in Fig. 2B-3, if the mixing ratio of the R, G, and B components is $G : B : R = 1 : 1 : 1$, peaks as AF signals are present at the R, G, and B positions, and the AF operation may stop at one of the peak positions.

As shown in Fig. 2C-3, when the mixing ratio is set to $G : B : R = 1 : 0.5 : 0.1$, the peaks can converge to one point, so the focus position can be detected on the basis of the signal component which is contained in the video signal at a high ratio.

Fig. 3 is a graph showing a detailed example of a change in mixing ratio on the basis of the magnitudes of positional shifts of the R and B components with respect to the G component due to chromatic aberrations.

For example, if the ratio of the G component is 1.0, ratios are obtained from an aberration $\Delta G-R$ between the G and R components and an aberration $\Delta G-B$ between the G and B components, and the ratio $G : R : B$ is set to $1 : 1 : 1$ or $1 : 0 : 0$. These ratios may be prepared as a table in the control circuit 7 or calculated. The detailed numerical values are not limited to those described above, and the values may be

externally rewritten.

For a zoom lens (RFZ lens 102), the chromatic aberration changes depending on the zoom position. For this reason, when chromatic aberrations corresponding to the zoom positions are stored in the chromatic aberration information storage section 15 in advance, the AF operation can be performed at an appropriate mixing ratio G : R : B for any zoom position.

The control processing procedure of the first
embodiment will be described with reference to the flow
chart shown in Fig. 4. In step S1, the control circuit
7 receives lens position information of the RFZ lens
102 and the like from the lens position detection
circuit 23. In step S2 (to be simply referred to as S2
hereinafter), the control circuit 7 receives pieces of
chromatic aberration information corresponding to the
pieces of lens position information read in S1 from the
chromatic aberration information storage section 15.
In S3, the control circuit 7 calculates the AF
generation ratio of the R, G, and B components. In S4,
the calculation result obtained in S3 is output to the
process circuit 13. In S5, the AF signal generation
circuit 14 generates an AF signal from the calculation
result. In S6, the control circuit 7 causes the AF
section 16 to receive the output from the process
circuit 13. In S7, the AF section 16 executes

calculation for predetermined AF control. In S8, the AF section 16 performs focus driving on the basis of the calculation result obtained in S7.

(Second Embodiment)

5 The second embodiment will be described next with reference to Fig. 5.

 The second embodiment is almost the same as the first embodiment. The same reference numerals as in the first embodiment denote the same members in the
10 second embodiment, and a detailed description thereof will be omitted. The second embodiment is different from the first embodiment in that aperture information obtained by an aperture detection circuit 6 is added
15 (portion 17) to chromatic aberration information from a chromatic aberration information storage section 15. Referring to Fig. 5, the control circuit 7 receives the output from the aperture detection circuit 6, adds the output value to the chromatic aberration information, and changes the mixing ratio of R, G, and B components.

20 Fig. 6 shows an example in which the F-number from the aperture detection circuit 6 is F1.8 representing a full-aperture state. Fig. 7 shows an example of a stopped-down-aperture state having an F-number of F16.

25 Fig. 6A-1 shows the shift amounts between the R, G, and B components on the imaging plane due to

the G component, the larger the defocus state becomes. As shown in Fig. 6C-2, when the mixing ratio of the R, G, and B components is set to 1 : 1 : 0.3, the peaks can converge to one point, so the focus position can be detected on the basis of the signal component which is contained in the video signal at a high ratio. When the signal component ratio in the video signal is known in advance, it can be determined which color component signal is to be used as a major component for AF signal generation.

Fig. 6A-3 shows a state wherein no best peak position is obtained on one imaging plane because of the chromatic aberrations in the telephoto region at an F-number of F1.8. AF signal peaks based on the R, G, and B video signal components are present on different imaging planes. As shown in Fig. 6B-3, if the mixing ratio of the components is 1 : 1 : 1, peaks as AF signals are present at the R, G, and B positions, and the AF operation may stop at one of the peak positions. As shown in Fig. 6C-3, when the mixing ratio is set to 1 : 0.5 : 0.1, the peaks can converge to one point, so the focus position can be detected on the basis of the signal component which is contained in the video signal at a high ratio.

25 When the F-number is F16, as shown in Fig. 7, the
depth is larger than for F1.8 in all of the wide-angle

state shown in Fig. 7D-1, middle state shown in
Fig. 7D-2, and telephoto state shown in Fig. 7D-3.

Even when the mixing ratio of the R, G, and B
components are set to 1 : 1 : 1, as shown in Figs. 7E-1,
5 7E-2, and 7E-3, to cover the aberrations between the R,
G, and B components, one peak is output. Hence, this
ratio is preferable for the AF signal.

As shown in Figs. 6 and 7, when the full-aperture
state is almost set (small F-number), the mixing ratio
10 of the R, G, and B components is appropriately changed
from 1 : 1 : 1 on the basis of the chromatic aberration
information. As the stopped-down-aperture state is set
(F-number becomes large), the mixing ratio is made
close to 1 : 1 : 1. Thus, by changing the mixing ratio
15 in accordance with the F-number, an optimum AF signal
is generated.

Fig. 8 is a graph showing a detailed example of a
change in ratio on the basis of the magnitudes of
positional shifts of the R and B components with
20 respect to the G component due to chromatic aberrations
and F-number.

As is apparent from Fig. 8, when it is assumed
that the ratio of the G component is 1.0, and the
F-number is small, ratios are set low, or when the
25 F-number is large, ratios are set close to 1.0 even
when the aberrations are equal in obtaining the ratios

S29, the AF section 16 performs focus driving on the basis of the calculation result obtained in S28.
(Third Embodiment)

The third embodiment will be described next with
5 reference to Fig. 10.

The third embodiment is almost the same as the first embodiment. The same reference numerals as in the first embodiment denote the same members in the third embodiment, and a detailed description thereof
10 will be omitted. The third embodiment is different from the first embodiment in that the lens system uses an interchangeable lens, and chromatic aberration information of a zoom lens (RFZ lens 102 or the like) is transmitted from a lens unit 20 to a camera unit 30.
15 A second control circuit 17 of the camera unit 30 transmits the output from a process circuit 13 for generating a focus signal for the AF operation and the output for the aperture operation to a first control circuit 7 of the lens unit 20 through a camera contact
20 18 and lens contact 19. The first control circuit 7 performs the AF or aperture operation on the basis of the information and transmits the zoom position, focus position, and aperture position to the second control circuit 17. Thus, the first control circuit 7 and
25 second control circuit 17 transmit/receive information.

The control processing procedure of the third

used not only for the AF operation but also for various other application purposes.

(Fourth Embodiment)

The fourth embodiment will be described next with
5 reference to Fig. 10.

The fourth embodiment is almost the same as the third embodiment. The same reference numerals as in the third embodiment denote the same members in the fourth embodiment, and a detailed description thereof
10 will be omitted. The fourth embodiment is different from the third embodiment in that aperture information of a zoom lens (RFZ lens 102) and the like are transmitted from a lens unit 20 to a camera unit 30, aperture information of the lens is also transmitted,
15 and the mixing ratio of R, G, and B components of an AF signal is calculated on the camera unit 30 side on the basis of the chromatic aberration information and F-number.

The control processing procedure of the fourth
20 embodiment will be described with reference to Fig. 10 and the flow chart shown in Fig. 12.

In S41, a first control circuit 7 receives lens position information of the RFZ lens 102 and the like from a lens position detection circuit 23. In S42, the
25 control circuit 7 receives pieces of chromatic aberration information corresponding to the pieces of

lens position information read in S41 from a chromatic aberration information storage section 15. In S43, the first control circuit 7 receives aperture information from an aperture detection circuit 6. In S44, the first control circuit 7 transmits the received chromatic aberration information and aperture information to the camera unit 30. In S45, a second control circuit 17 calculates the AF generation ratio of the R, G, and B components on the basis of the received chromatic aberration information in consideration of the aperture information. In S46, the second control circuit 17 outputs the calculation result obtained in S45 to a process circuit 13. In S47, an AF signal generation circuit 14 generates an AF signal from the calculation result. In S48, the second control circuit 17 receives the AF signal output from the process circuit 13. In S49, the received AF signal is transmitted to an AF section 16 of the lens unit 20. In S50, the AF section 16 executes calculation for predetermined AF control. In S51, the AF section 16 performs focus driving on the basis of the calculation result obtained in S50.

(Fifth Embodiment)

The fifth embodiment will be described next with
25 reference to Fig. 10.

The fifth embodiment is almost the same as the

third embodiment. The same reference numerals as in the third embodiment denote the same members in the fifth embodiment, and a detailed description thereof will be omitted. The fifth embodiment is different
5 from the third embodiment in that the mixing ratio of R, G, and B components for AF signal generation is calculated on the basis of optical information such as chromatic aberration information of a zoom lens (RFZ lens 102) and the like and aperture information, the
10 calculation result is transmitted to a camera unit 30, and the AF signal is generated on the camera unit 30 side.

The control processing procedure of the fifth embodiment will be described with reference to Fig. 10
15 and the flow chart shown in Fig. 13.

In S52, a first control circuit 7 receives lens position information of the RFZ lens 102 and the like from a lens position detection circuit 23. In S53, the control circuit 7 receives pieces of chromatic
20 aberration information corresponding to the pieces of lens position information read in S53 from a chromatic aberration information storage section 15. In S54, the first control circuit 7 receives optical information such as aperture information from an aperture detection
25 circuit 6. In S55, the first control circuit 7 calculates the AF generation ratio of R, G, and B

components on the basis of the received chromatic
aberration information and optical information. In S56,
the calculation result is transmitted to the camera
unit 30. In S57, a second control circuit 17 outputs
5 the received calculation result to a process circuit 13.
In S58, an AF signal generation circuit 14 generates an
AF signal from the calculation result. In S59, the
second control circuit 17 receives the AF signal output
from the process circuit 13. In S60, the received AF
10 signal is transmitted to an AF section 16 of a lens
unit 20. In S61, the AF section 16 executes
calculation for predetermined AF control. In S62, the
AF section 16 performs focus driving on the basis of
the calculation result obtained in S61.

15 (Sixth Embodiment)

Fig. 14 is a block diagram showing the sixth
embodiment.

A camera unit control circuit 217 of a camera
unit transmits the output from a process circuit 213
20 for generating a focus signal for AF and the output for
the aperture operation to a lens unit control circuit
207 through a camera contact 218 and adapter camera
side contact 221, and an adapter lens side contact 222
and a lens contact 219. An adapter 220 has a contact
25 for identifying the pieces of information at the
adapter lens side contact 222. The adapter 220

each lens group is not particularly limited. In addition, the adapter 220 is not particularly limited, and it may have or omit an optical system for, e.g., increasing the zoom magnification, an optical system
5 for obtaining a closeup object sensing effect, a means for converting data without using any optical system by directly passing a light beam, or a flange-back adapter.

The image of a red (R) component of the three primary colors of a light beam from an object is formed
10 on an image sensing element 202-1 such as a CCD, the image of a green (G) component is formed on an image sensing element 202-2 such as a CCD, and the image of a blue (B) component is formed on an image sensing element 202-3 such as a CCD.

15 An aperture member 203 adjusts the amount of light incident on an photoelectric conversion element 202. An aperture driving unit 204 drives the aperture member 203 under the control of the control circuit 207 such that a predetermined amount of light is incident
20 on the photoelectric conversion element 202. Reference numeral 205 denotes an aperture position detector. A detection circuit 206 detects the output from the aperture position detector 205 and outputs the signal to the control circuit 207.

25 Driving units 208 and 209 such as stepping motors drive the movable lens groups 302 and 304, respectively.

Drivers 210 and 211 drive the driving units 208 and 209, respectively.

An amplifier 212 amplifies the output from the photoelectric conversion element 202. A process
5 circuit 213 has an automatic focusing (to be referred to as AF hereinafter) signal generation circuit 14 for converting a signal into a signal such as an NTSC video signal and mixing R, G, and B video outputs at an arbitrary ratio to generate an AF signal for the AF
10 operation. A storage means 215 stores chromatic aberration information of each lens in advance. When the adapter 220 is attached, the storage means 215 may have chromatic information including information of the adapter 220. Alternatively, when the adapter is
15 attached, the chromatic aberration information may be calculated in the lens unit control circuit 207 on the basis of the information from the lens chromatic information storage means and the presence/absence of the adapter. An AF section 216 causes the apparatus to
20 perform the AF operation in accordance with the AF signal from the AF signal generation circuit 214 and the output from the chromatic aberration information storage means 215. The AF scheme is known, as described above, and a detailed description thereof
25 will be omitted.

In this embodiment, chromatic aberration of a

lens is prepared as information in advance, and even when the adapter is attached, the mixing ratio of the R, G, and B components is actively changed in generating an AF signal in accordance with the chromatic

5 aberration information including information of the adapter, thereby implementing AF capable of always detecting the best peak position without any blur.

This will be described with reference to Fig. 15.

Fig. 15A-1 shows the shift amounts between the R, G, and B components on the imaging plane in the wide-angle state.

In this case, the shifts between the R, G, and B components are small. Hence, even when the ratio of the R, G, and B components of the AF signal is $G : B : R = 1 : 1 : 1$, only one peak position is obviously present. However, since the R, G, and B components do not completely match, the gradient of the output peak of the AF signal is almost flat, as shown in Fig. 15B-1, and the actual peak position can hardly be detected by the AF operation. As shown in Fig. 15C-1, when the mixing ratio of the R, G, and B components is set to $G : B : R = 1 : 0.9 : 0.8$, the peak can easily be detected. Detailed examples of numerical values of the R, G, and B mixing ratio to be described below are merely examples for a descriptive convenience and are not limited to those values.

Fig. 15A-2 shows a state wherein the R, G, and B components do not form images at the best peak position on the same plane, the R and B components are close to each other, and the G component is separated

5 If the mixing ratio of the R, G, and B signal components is 1 : 1 : 1, two peaks as AF signals are present at two points: a point near the R and B components and a point corresponding to the G component, and the AF operation can stop at any peak position.

10 Generally, a video signal contains the G component at a high ratio, so the G peak position is close to the best focus position for the human eye. Hence, the farther the position where the AF operation stops is separated from the G component, the larger the
15 defocus state becomes.

As shown in Fig. 15C-2, when the mixing ratio is set to $G : B : R = 1 : 1 : 0.3$, the peaks can converge to one point, so the focus position can be detected on the basis of the signal component which is contained in
20 the video signal at a high ratio. When the signal component ratio in the video signal is known in advance, it can be determined which color component signal is to be used as a major component for AF signal generation.

Fig. 15A-3 shows a state wherein no best peak
25 position is obtained on one imaging plane because of the chromatic aberrations in the telephoto region. AF

signal peaks based on the R, G, and B video signal components are present on different imaging planes.

If the ratio is 1 : 1 : 1, peaks as AF signals are present at the R, G, and B positions, and the AF operation can stop at any peak position.

As shown in Fig. 15C-3, when the mixing ratio is set to $G : B : R = 1 : 0.5 : 0.1$, the peaks can converge to one point, so the focus position can be detected on the basis of the signal component which is contained in the video signal at a high ratio.

Fig. 16 is a graph showing a detailed example of a change in mixing ratio on the basis of the magnitudes of positional shifts of the R and B components with respect to the G component.

For example, if the ratio of the G component is 1.0, ratios are obtained from an aberration $\Delta G-R$ between the G and R components and an aberration $\Delta G-B$ between the G and B components, and the ratio $G : B : R$ is set to 1 : 1 : 1 or 1 : 0.0 : 0.0. These ratios may be prepared as a table in the control circuit or calculated. The detailed numerical values are not limited to those described above, and the values may be externally rewritten.

For a zoom lens, the chromatic aberration changes depending on the zoom position. For this reason, when chromatic aberrations corresponding to the zoom

positions are stored in advance, and pieces of
chromatic aberration information corresponding to the
zoom positions are stored, the AF operation can be
performed at an appropriate mixing ratio for any zoom
5 position.

Fig. 17 is a flow chart.

In S101, it is detected on the basis of the
signal from the identification circuit 222 whether the
adapter is attached between the lens and the camera,
10 and the type of adapter is detected if it is attached.
In S102, the zoom position information of the lens is
received. In S103, chromatic aberration information
corresponding to the detection result received in S101
and zoom position information received in S102 is
15 received. In S104, the AF generation ratio is
calculated. In S105, the calculation result obtained
in S104 is output. In S106, the AF signal is generated.
In S107, the output from the process circuit 213 is
received. In S108, calculation for predetermined AF
20 control is executed. In S109, focus driving is
performed on the basis of the calculation result
obtained in S108.

In this embodiment, an arrangement using image
sensing elements of 3-CCD scheme has been described.
25 However, an image formation position shift due to
chromatic aberration also occurs in a single CCD. AF

numerals as in the sixth embodiment will be omitted.

Referring to Fig. 18, an adapter 224 having an optical system is, e.g., a closeup lens for reducing the focusible object distance of the lens 201. A

5 detection circuit 225 detects whether the adapter 224 is attached. Upon detecting that the adapter 224 is attached to the front portion of the lens on the basis of the output from the detection circuit 225, a control circuit 207 obtains the chromatic aberration
10 information of the lens system including the lens 201 and adapter 224 on the basis of stored information or stored information and calculation. In accordance with the chromatic aberration information output, the AF signal generation ratio is calculated and generated to
15 execute AF control.

Fig. 19 is a flow chart.

In S121, the detection circuit 225 detects whether the adapter 224 is attached to the front portion of the lens. In S122, the zoom position
20 information of the lens is received. In S123, chromatic aberration information corresponding to the detection result received in S121 and zoom position information received in S122 is received. In S124, the AF generation ratio is calculated. In S125, the
25 calculation result obtained in S124 is output. In S126, the AF signal is generated. In S127, the output from

the process circuit 213 is received. In S128,
calculation for predetermined AF control is executed.
In S129, focus driving is performed on the basis of the
calculation result obtained in S128.

5 (Eighth Embodiment)

The eighth embodiment will be described.

Fig. 20 is a block diagram showing the eighth
embodiment. The same reference numerals as in the
sixth embodiment denote the same parts in the eighth
10 embodiment, and a detailed description thereof will be
omitted.

The object of this embodiment is to perform
control in consideration of chromatic aberration when
an optical system is attached in a lens 201. As in the
15 seventh embodiment, this embodiment does not use an
interchangeable lens, unlike the sixth embodiment.
Even when an interchangeable lens is used, as in the
sixth and seventh embodiments, the object is the same
as described above, and a detailed description of the
20 same reference numerals as in the sixth embodiment will
be omitted.

Referring to Fig. 20, an adapter 226 having an
optical system is, e.g., a wide attachment lens for
decreasing the focal length of the lens 201. A
25 detection circuit 227 detects whether the adapter 226
is attached in the lens. Upon detecting that the

(e.g., a copying machine, a facsimile apparatus, or the like).

The object of the present invention is realized even by supplying a medium such as a storage medium (or
5 recording medium) storing software program codes for realizing the functions of the above-described embodiments to a system or apparatus, and causing the computer (or a CPU or an MPU) of the system or apparatus to read out and execute the program codes stored in the
10 medium. In this case, the program codes read out from the medium realize the functions of the above-described embodiments by themselves, and the medium such as a storage medium storing the program codes constitutes the present invention. The functions of the above-described
15 embodiments are realized not only when the readout program codes are executed by the computer but also when the OS (Operating System) running on the computer performs part or all of actual processing on the basis of the instructions of the program codes.

20 The functions of the above-described embodiments are also realized when the program codes read out from the medium such as a storage medium are written in the memory of a function expansion board inserted into the computer or a function expansion unit connected to the
25 computer, and the CPU of the function expansion board or function expansion unit performs part or all of actual

processing on the basis of the instructions of the
program codes.

When the present invention is applied to the
medium such as a storage medium, it stores program
5 codes corresponding to the above-described flow chart
(shown in Fig. 4, 9, 11, 12, 13, 17, 19, or 21).

The embodiments of the present invention have
been described above. The present invention is not
limited to the contents disclosed in the above
10 embodiments and can be applied to any constitution as
long as it can implement the functions of the appended
claims or the functions of the embodiments.

For example, in the above embodiments, the AF
signal is formed in consideration of all the red, green,
15 and blue component signals. Only one (especially, the
green component signal) or two color component signals
may be used to form the AF signal, as needed.

The separated color component signals may be
different from those of the above embodiments, as
20 needed.

In the above embodiments, the separated color
component signals are resynthesized, and then, the AF
signal is formed. Instead, the AF signal may be formed
before or without resynthesis.

25 In the above embodiments, the chromatic
aberration information of the adapter is used together

WHAT IS CLAIMED IS:

1. A focus adjustment apparatus comprising:

a color component signal forming circuit for forming a plurality of color component signals

5 corresponding to predetermined different color components of object light received through an optical system; and

a focus adjustment signal forming circuit for forming a signal for focus adjustment on the basis of a
10 signal formed by changing a ratio of the plurality of color component signals formed by said color component signal forming circuit.

2. The apparatus according to claim 1, wherein the ratio of the plurality of color component signals
15 includes a case wherein a ratio of at least one color component signal is set to zero.

3. The apparatus according to claim 1, wherein said focus adjustment signal forming circuit forms the signal for focus adjustment on the basis of a signal
20 formed by synthesizing the plurality of color component signals in accordance with the ratio.

4. The apparatus according to 1, wherein said focus adjustment signal forming circuit changes the ratio of the plurality of color component signals on the basis
25 of chromatic aberration information of the optical system.

23. The apparatus according to claim 5, wherein the auxiliary optical system increases a focusible object distance of the optical system to a closeup side.

24. The apparatus according to claim 7, wherein the
5 auxiliary optical system increases a focusible object
distance of the optical system to a closeup side.

25. The apparatus according to claim 9, wherein the auxiliary optical system increases a focusible object distance of the optical system to a closeup side.

10 26. The apparatus according to claim 11, wherein the
auxiliary optical system increases a focusible object
distance of the optical system to a closeup side.

27. The apparatus according to claim 12, wherein the
auxiliary optical system increases a focusible object
15 distance of the optical system to a closeup side.

28. The apparatus according to claim 4, characterized by further comprising a storage unit for storing the chromatic aberration information.

29. The apparatus according to claim 28, wherein
20 said storage unit is provided in the optical
system,

said focus adjustment signal forming circuit is provided in an image sensing apparatus main body to which the optical system is attached, and

25 said apparatus further comprises a transmission
section for transmitting the chromatic aberration

system.

35. The apparatus according to claim 1, wherein said focus adjustment apparatus is provided in the image sensing apparatus main body to which the optical system is attached.

36. The apparatus according to claim 1, wherein said focus adjustment apparatus is provided in an image sensing system comprising the optical system and the image sensing apparatus main body to which the optical system is attached.

37. A focus adjustment method comprising the steps of:

forming a plurality of color component signals corresponding to predetermined different color components of object light received through an optical system; and

forming a signal for focus adjustment on the basis of a signal formed by changing a ratio of the plurality of color component signals formed.

38. A medium for supplying a focus adjustment control program, the control program comprising:

forming a plurality of color component signals corresponding to predetermined different color components of object light received through an optical system; and

forming a signal for focus adjustment on the

basis of a signal formed by changing a ratio of the plurality of color component signals formed.

39. The medium according to claim 38, wherein said medium comprises a storage medium.

ABSTRACT OF THE DISCLOSURE

This invention provides an apparatus such as a focus adjustment apparatus capable appropriately adjusting focusing in accordance with chromatic aberration, a control method therefor, and a medium such as a storage medium for supplying a control program therefor. An apparatus such as a focus adjustment apparatus which forms a plurality of color component signals corresponding to predetermined different color components of object light received through an optical system, and forms a signal for focus adjustment on the basis of a signal formed by changing a ratio of the plurality of color component signals formed, a control method therefor, and a medium such as a storage medium for supplying a control program therefor are provided.

FIG. 1

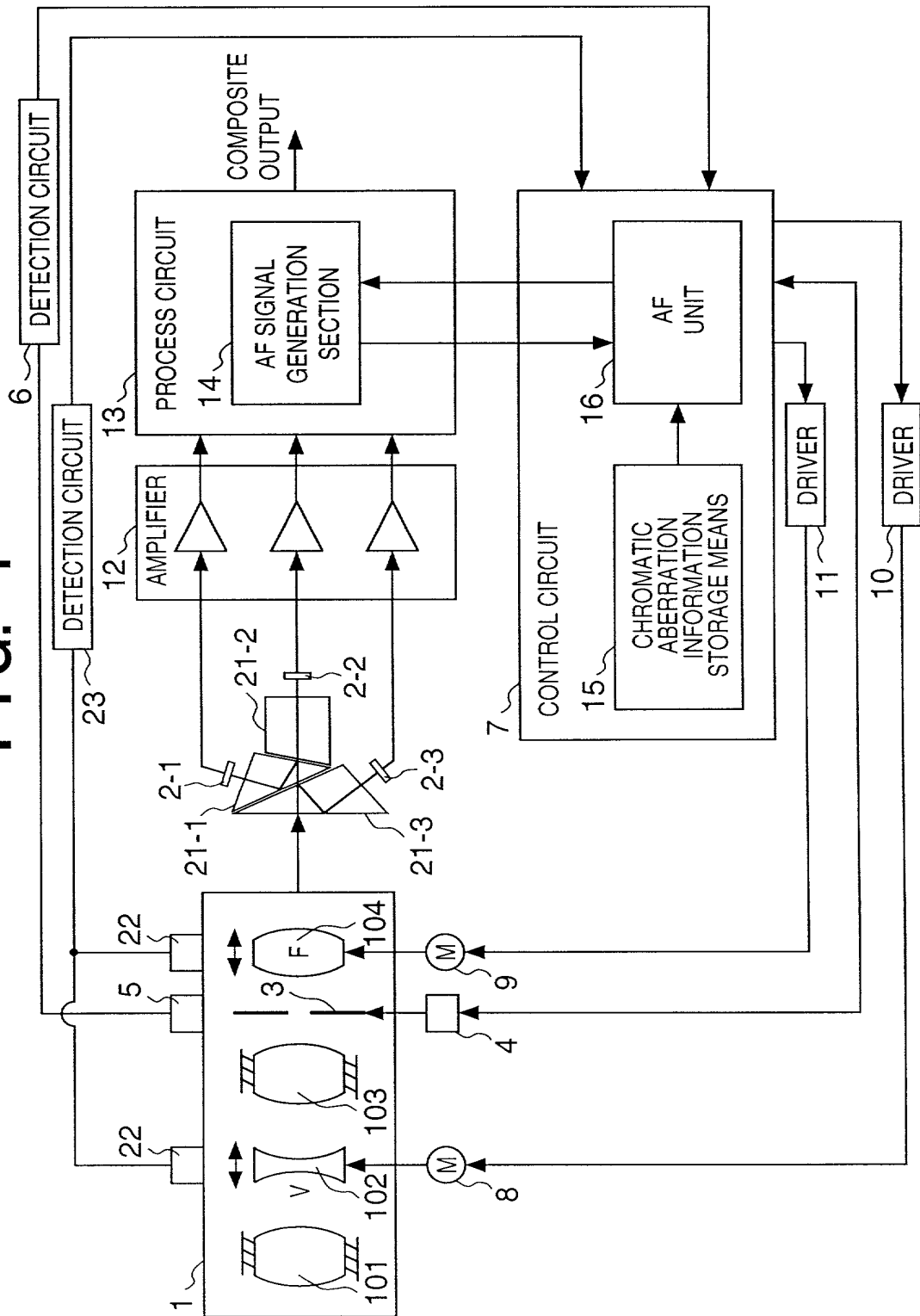


FIG. 2

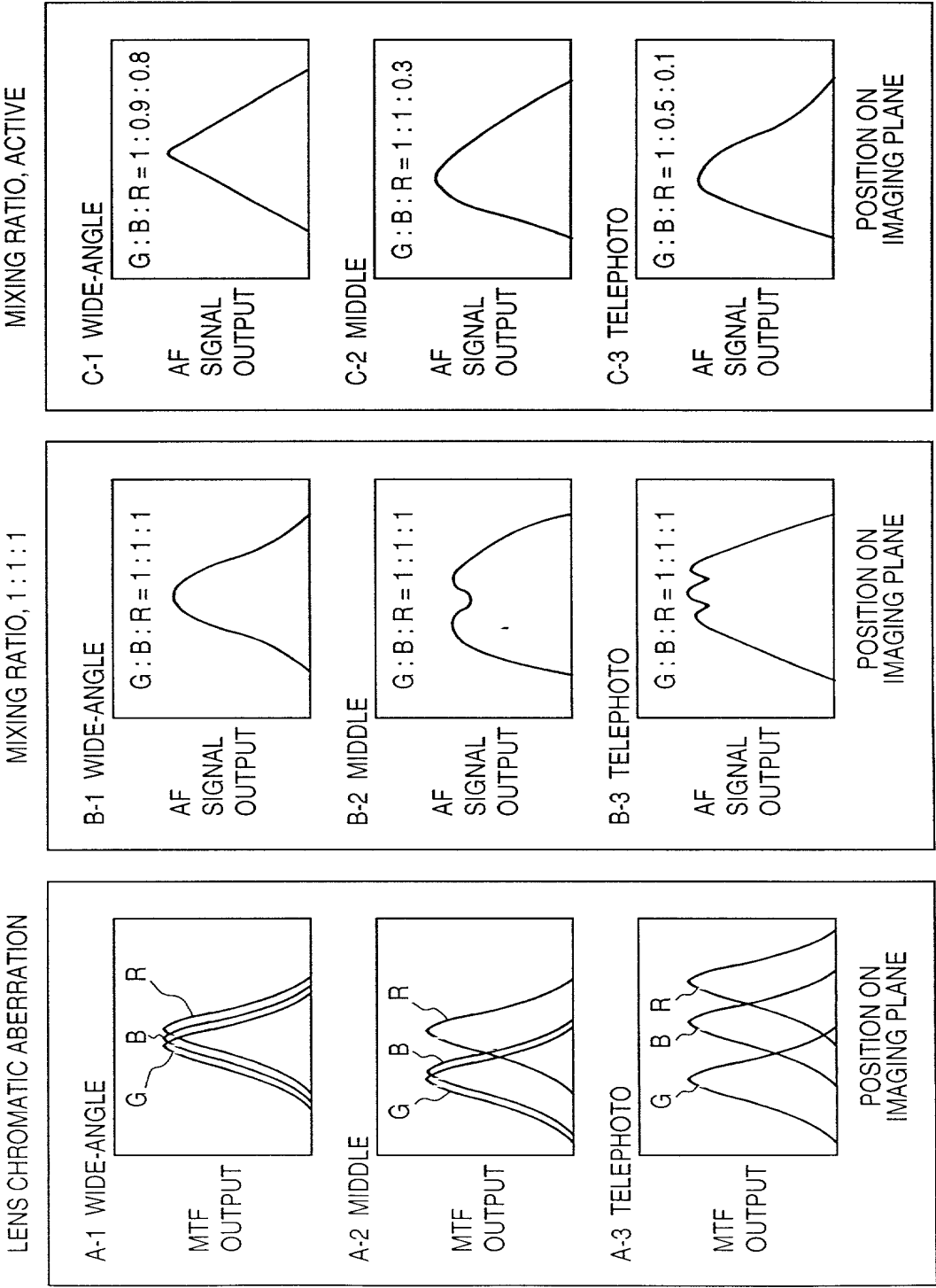


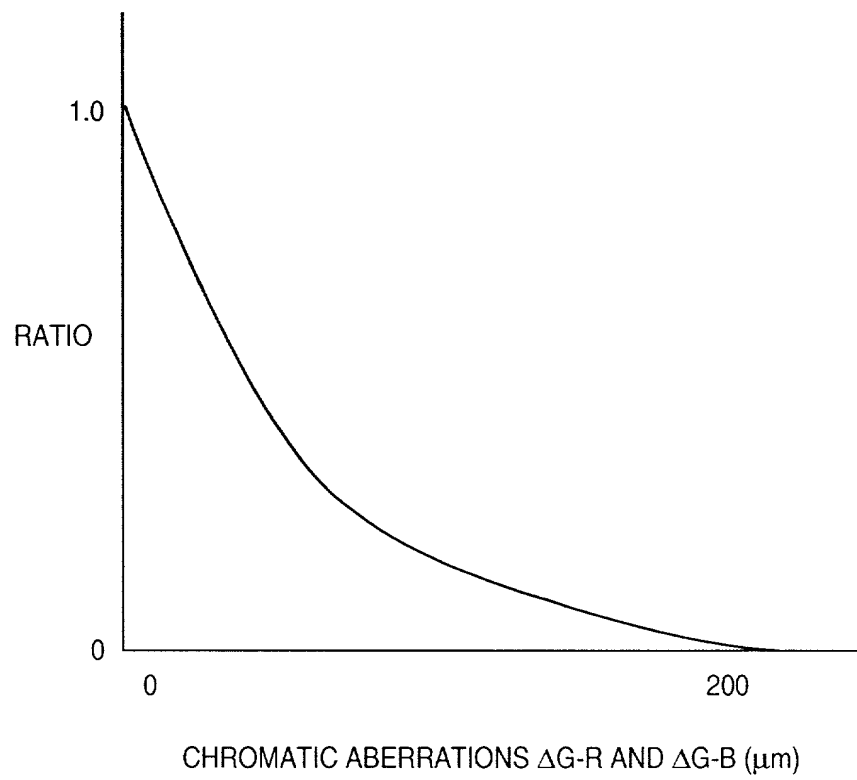
FIG. 3

FIG. 4

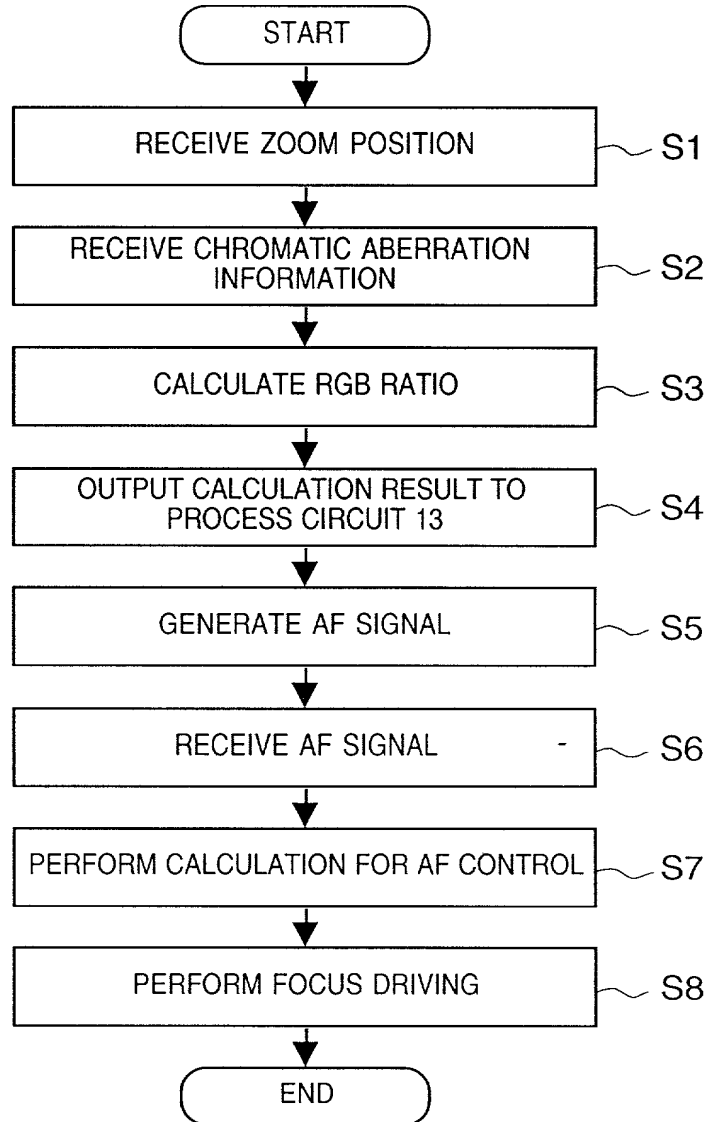


FIG. 5

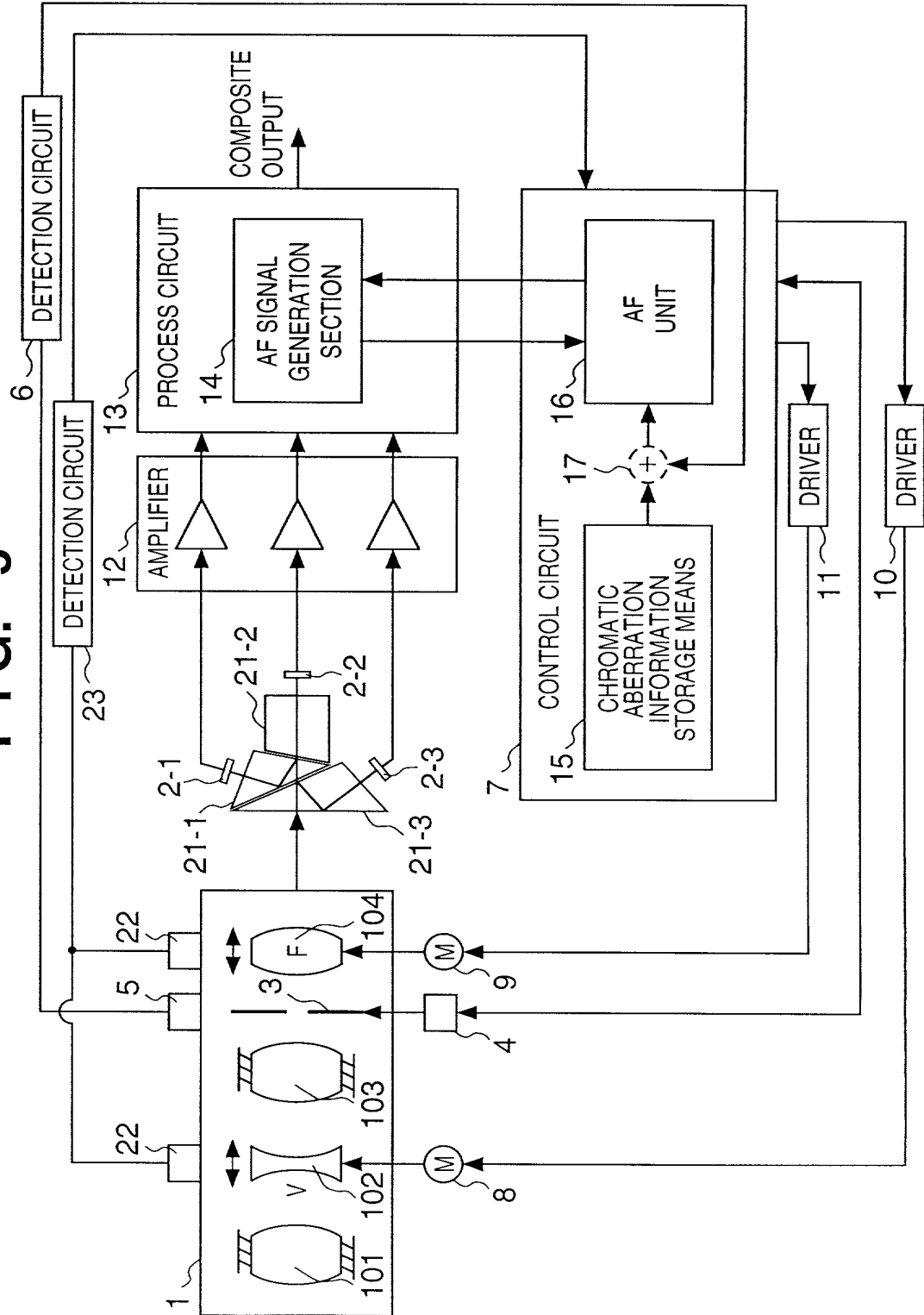


FIG. 6

< F-NUMBER : F1.8 >
LENS CHROMATIC ABERRATION

MIXING RATIO, ACTIVE

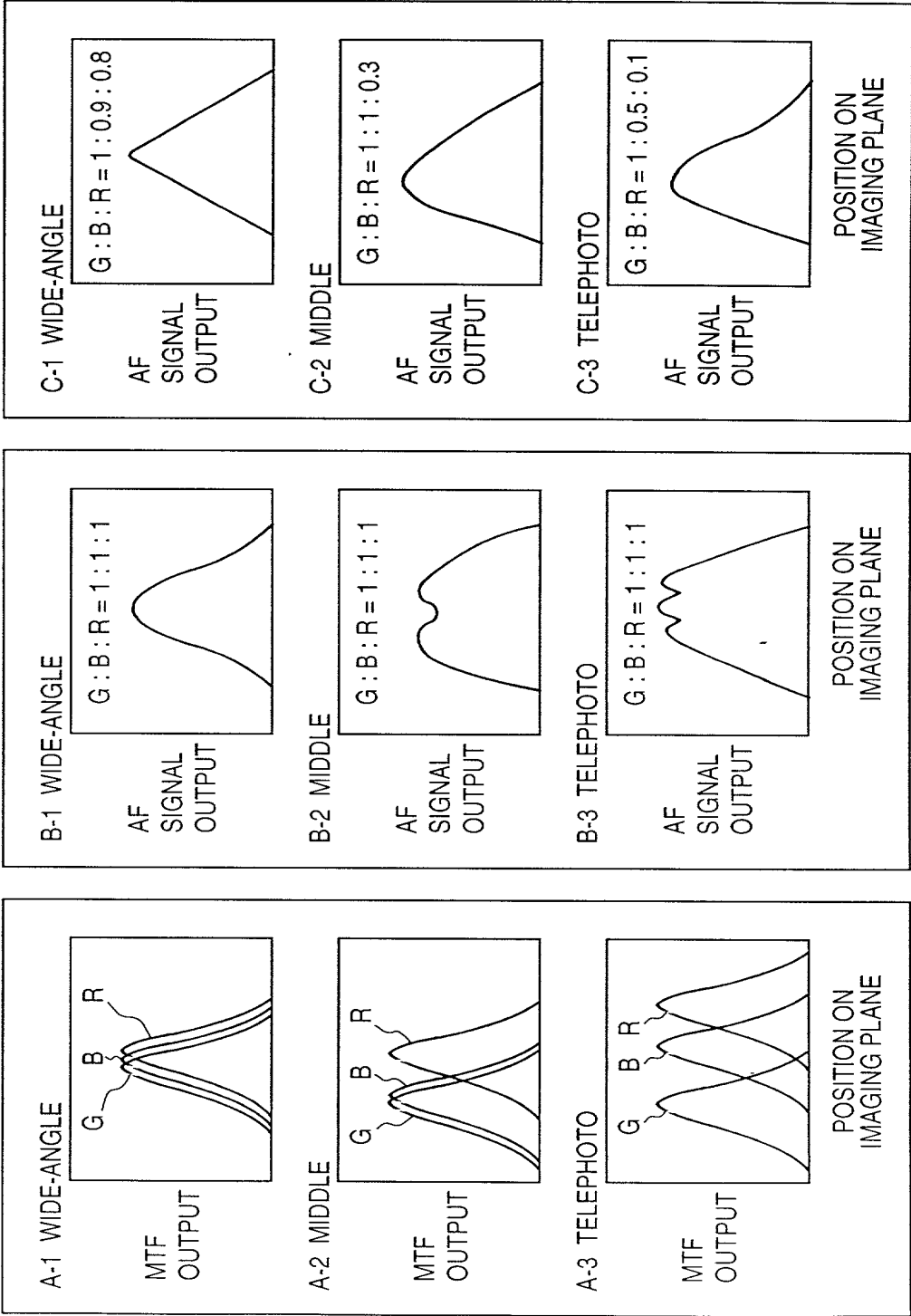


FIG. 7

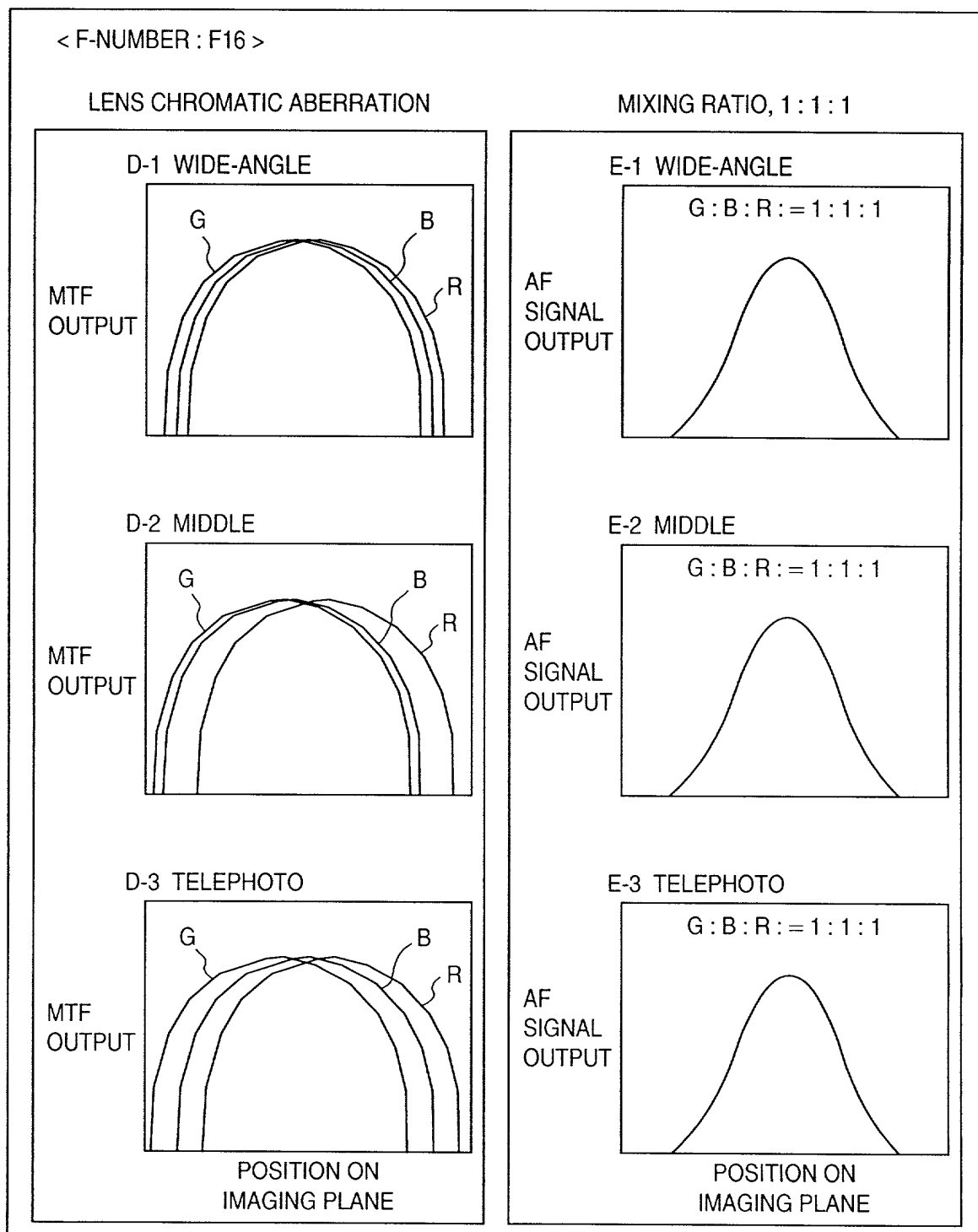


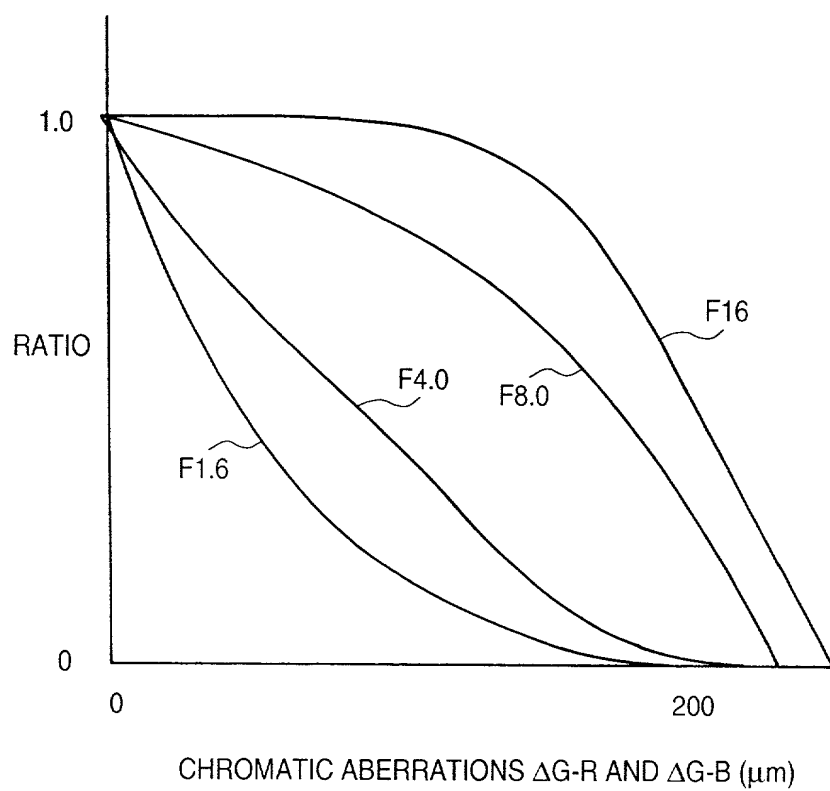
FIG. 8

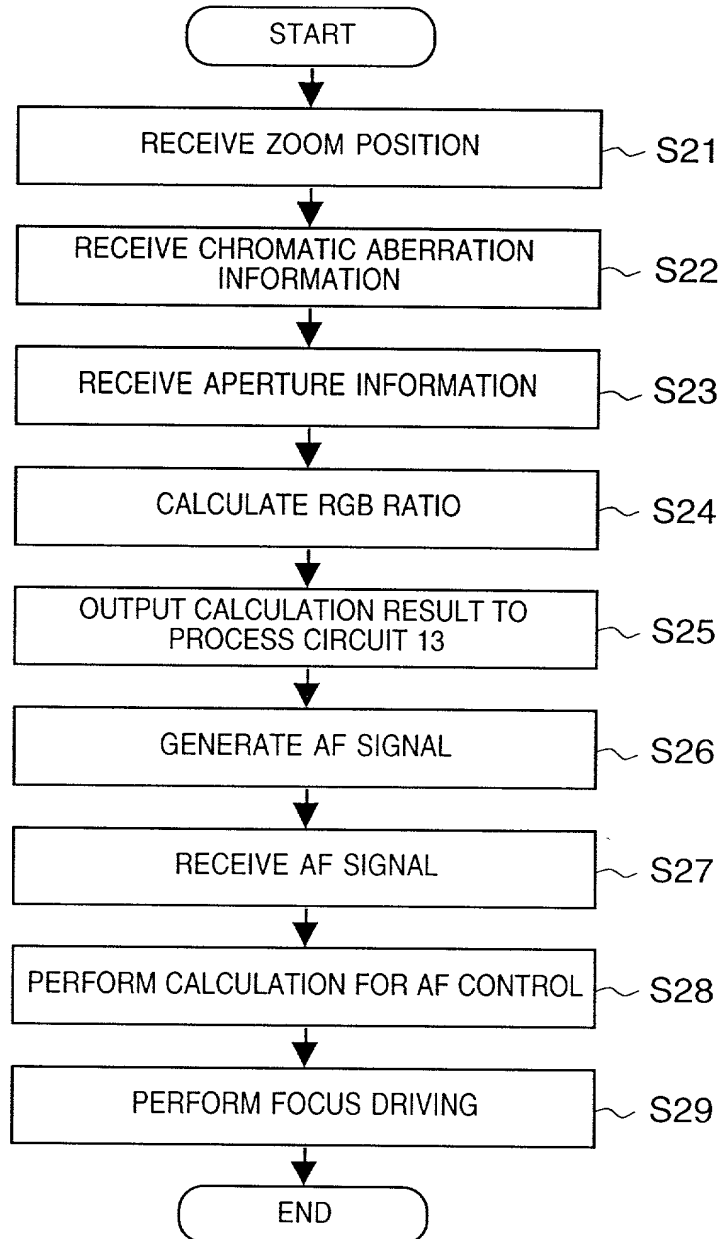
FIG. 9

FIG. 11

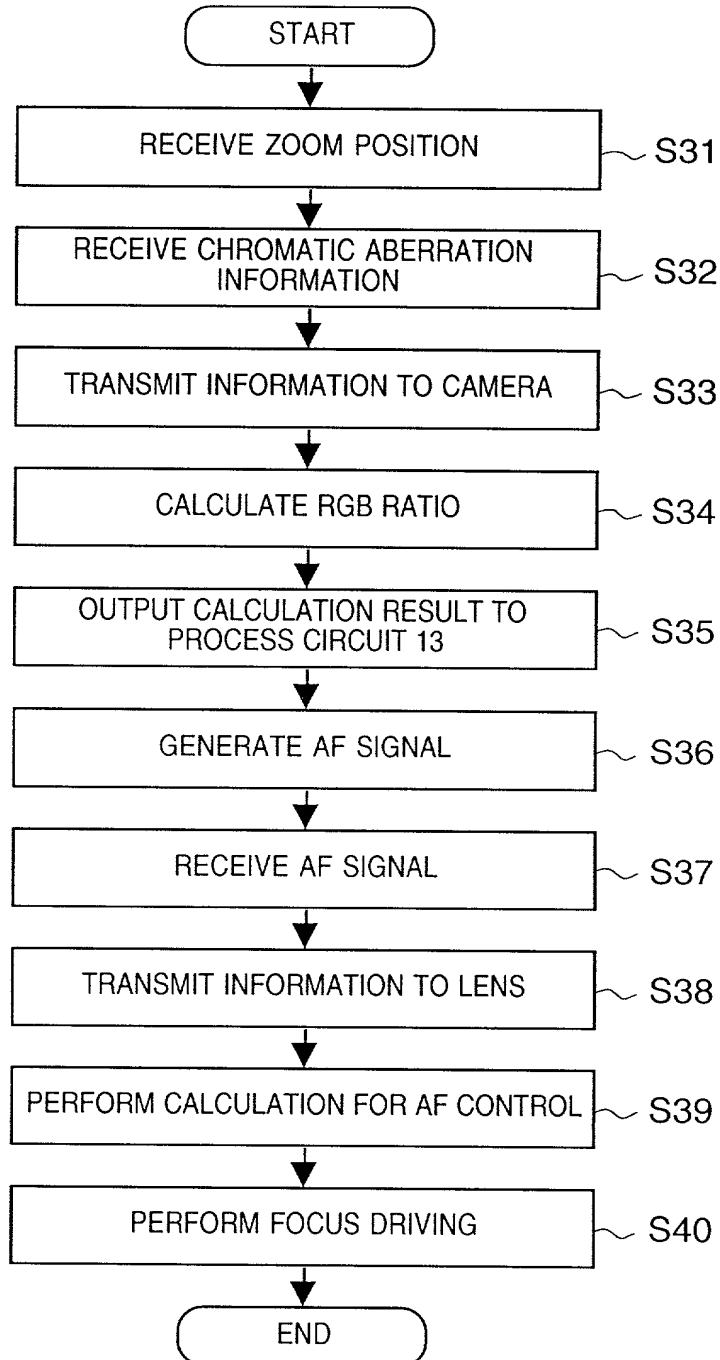


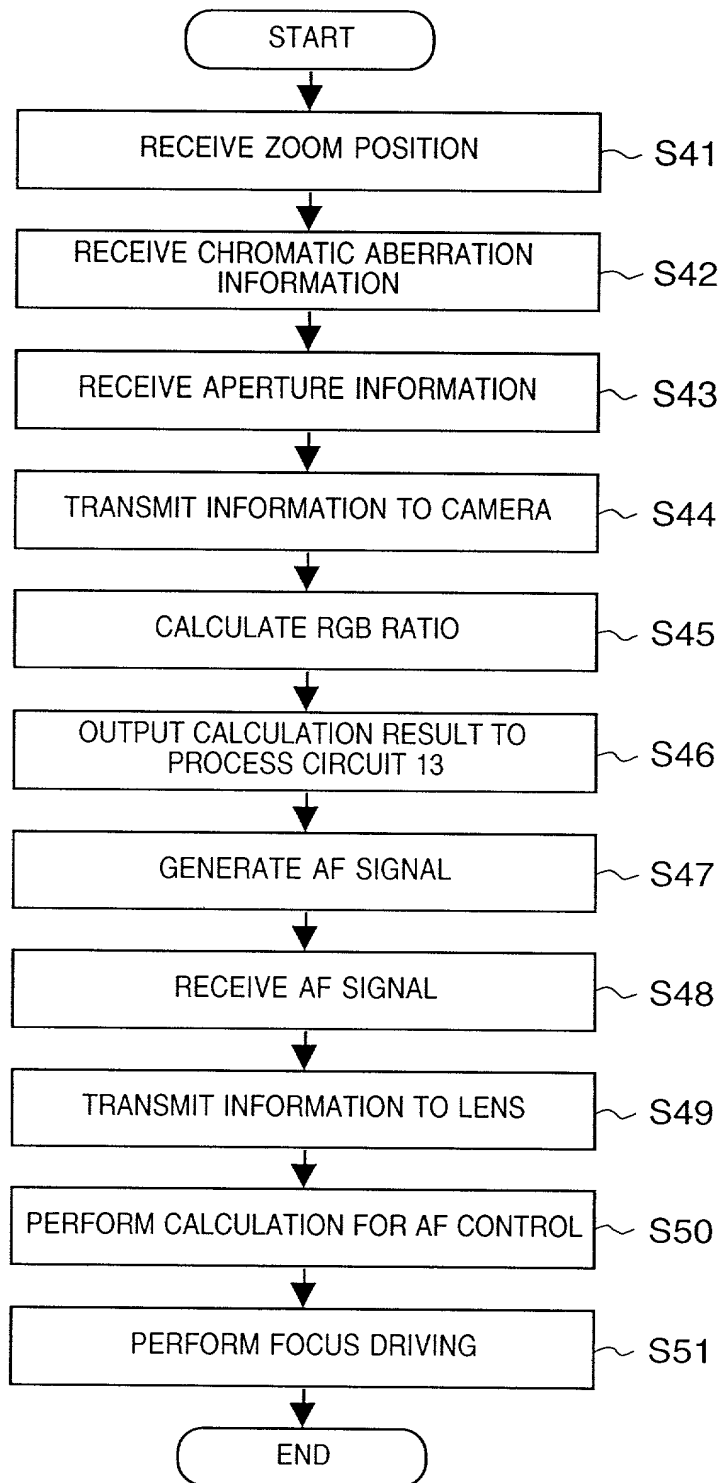
FIG. 12

FIG. 13

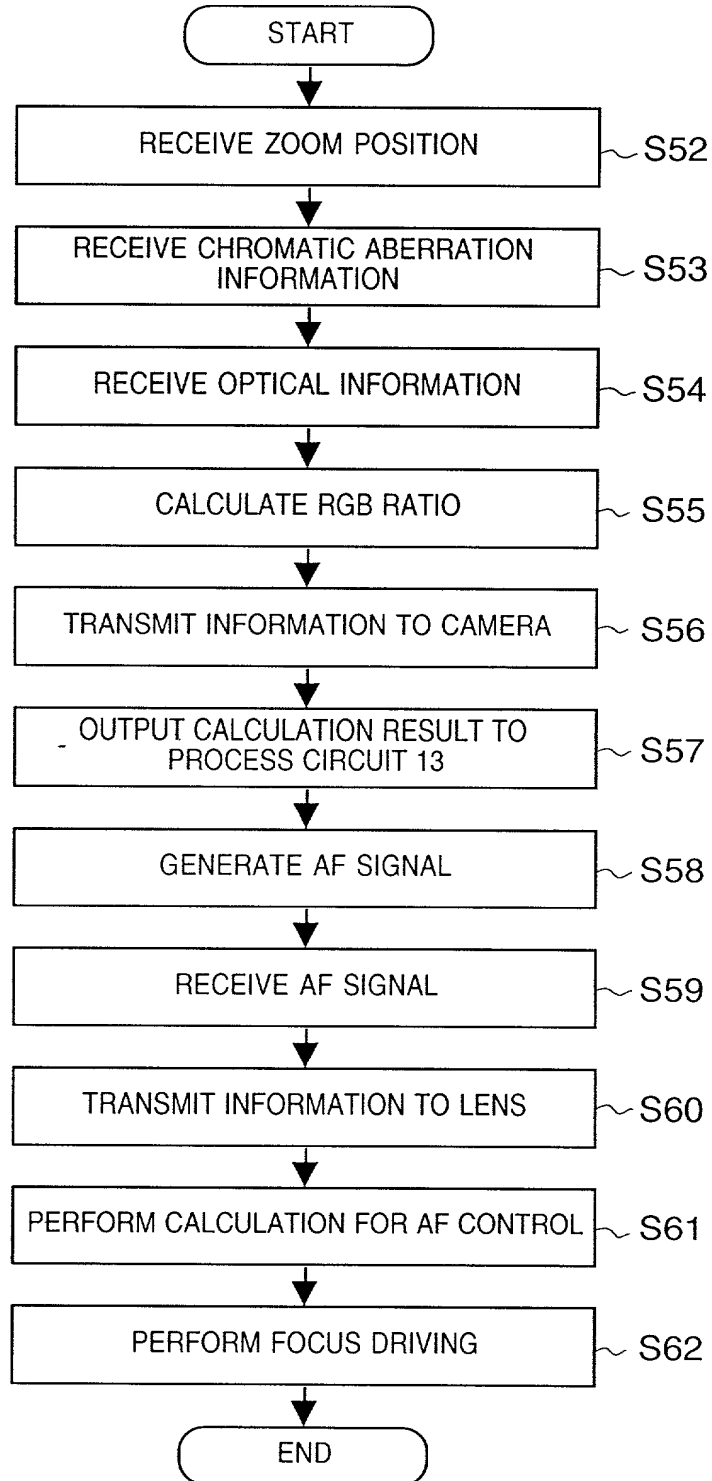


FIG. 14

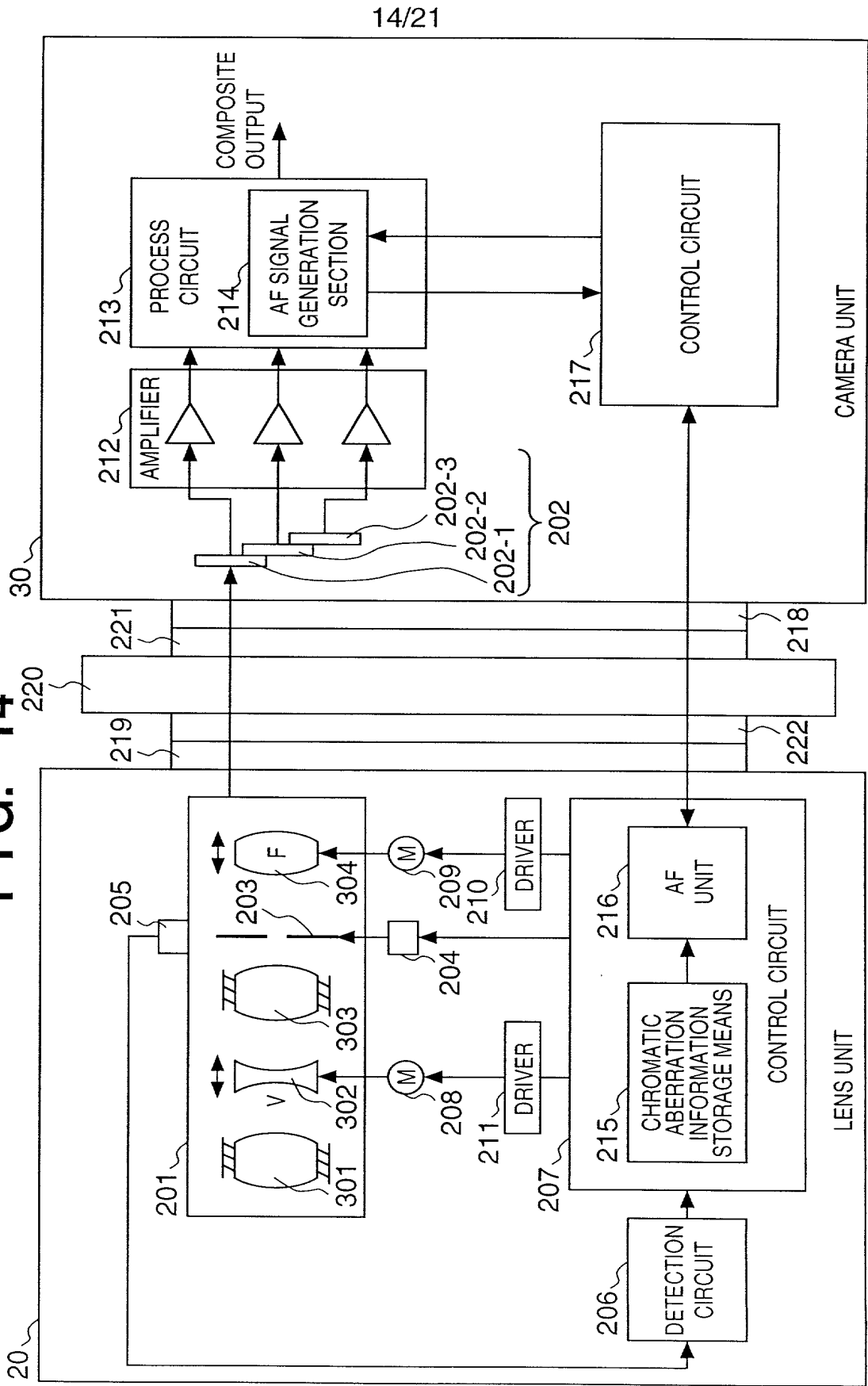


FIG. 15

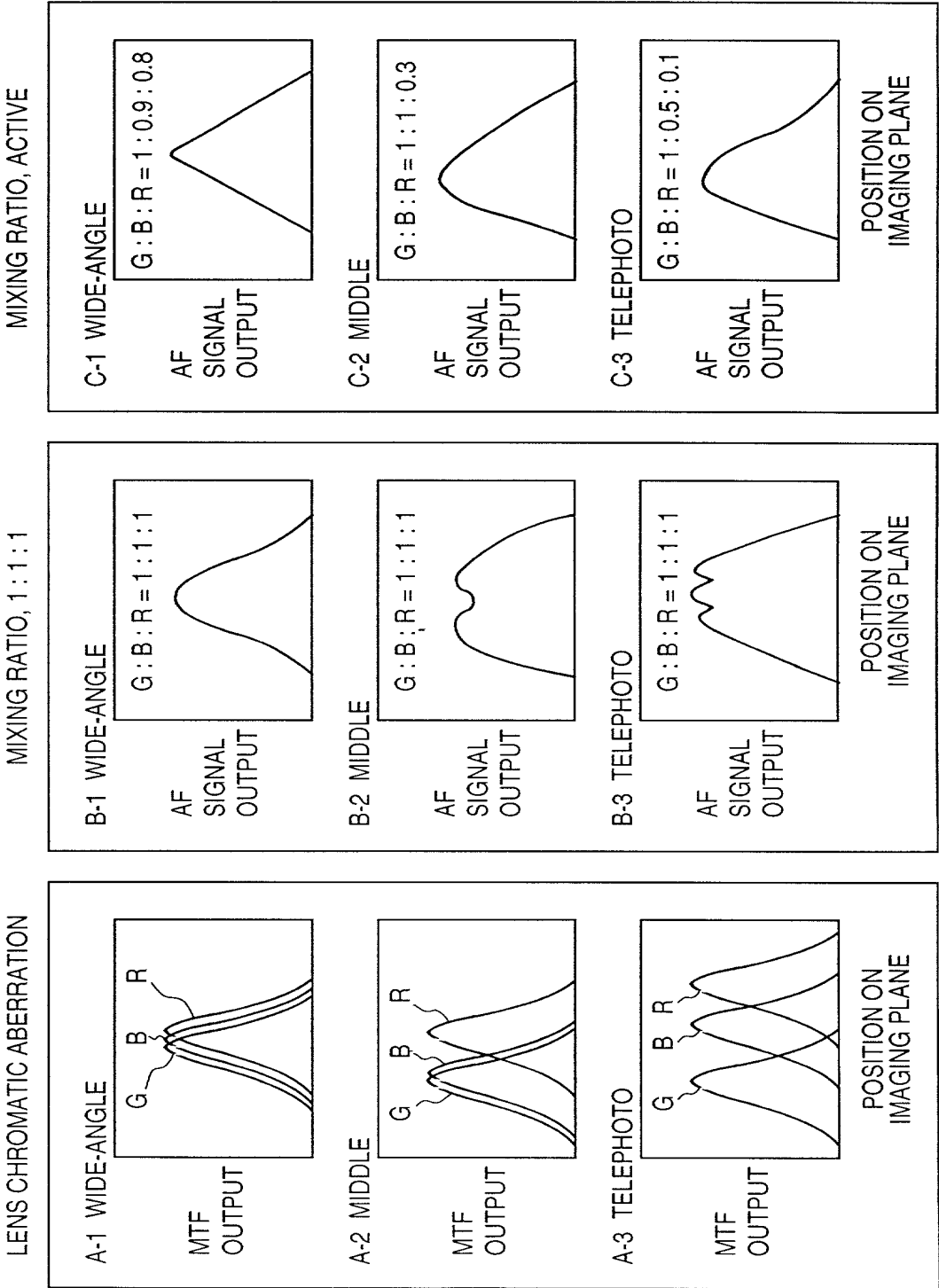


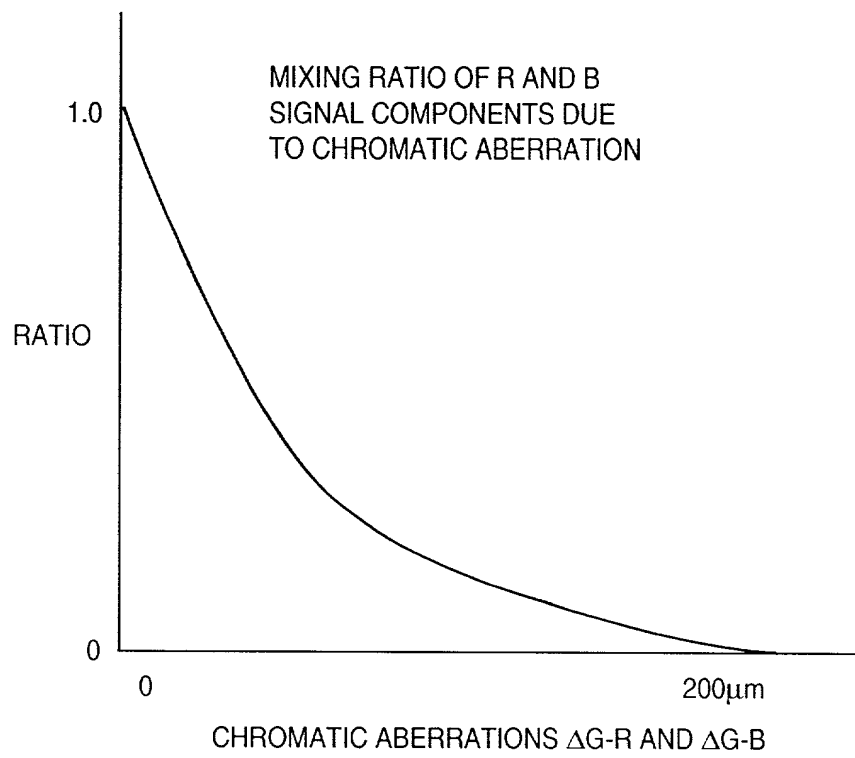
FIG. 16

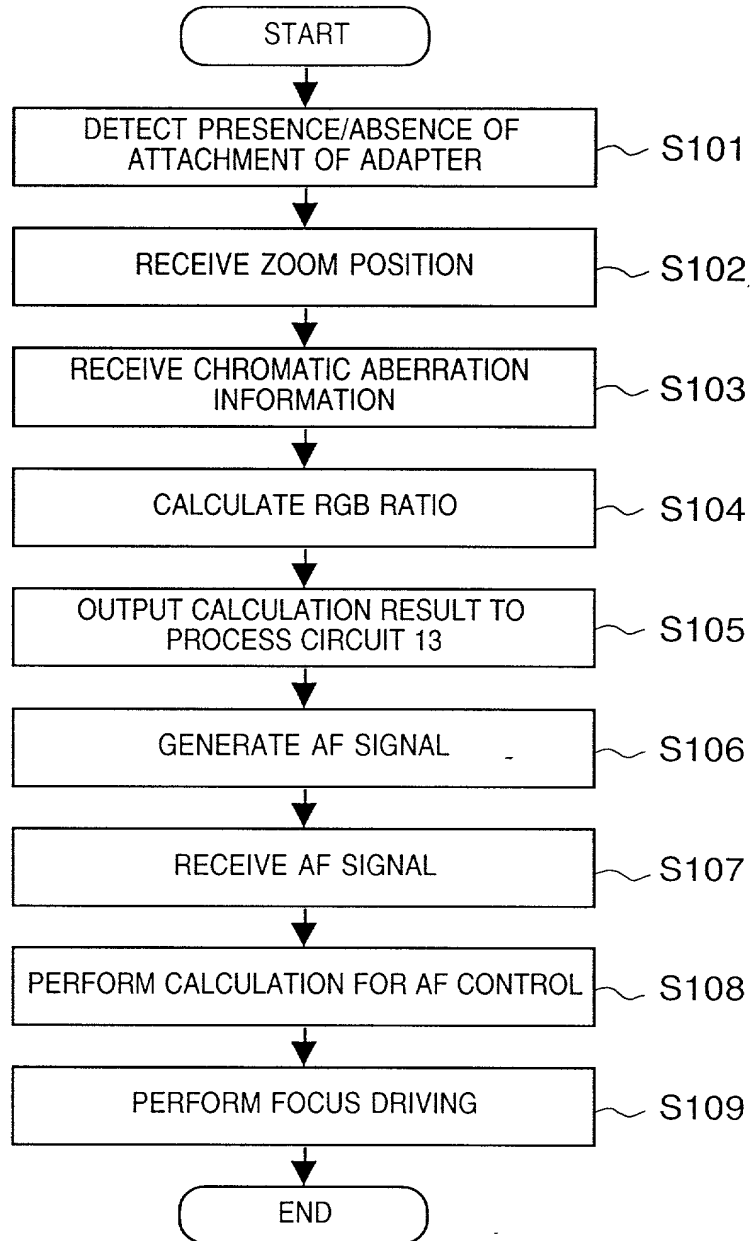
FIG. 17

FIG. 19

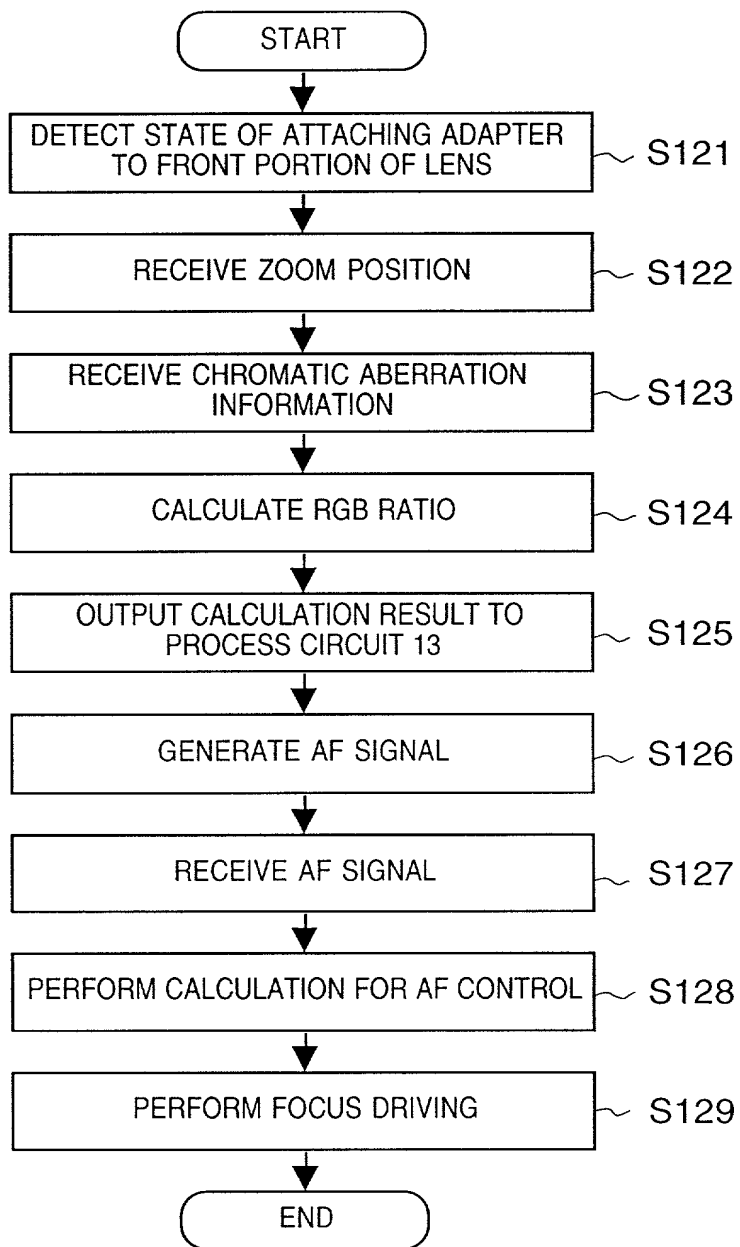


FIG. 20

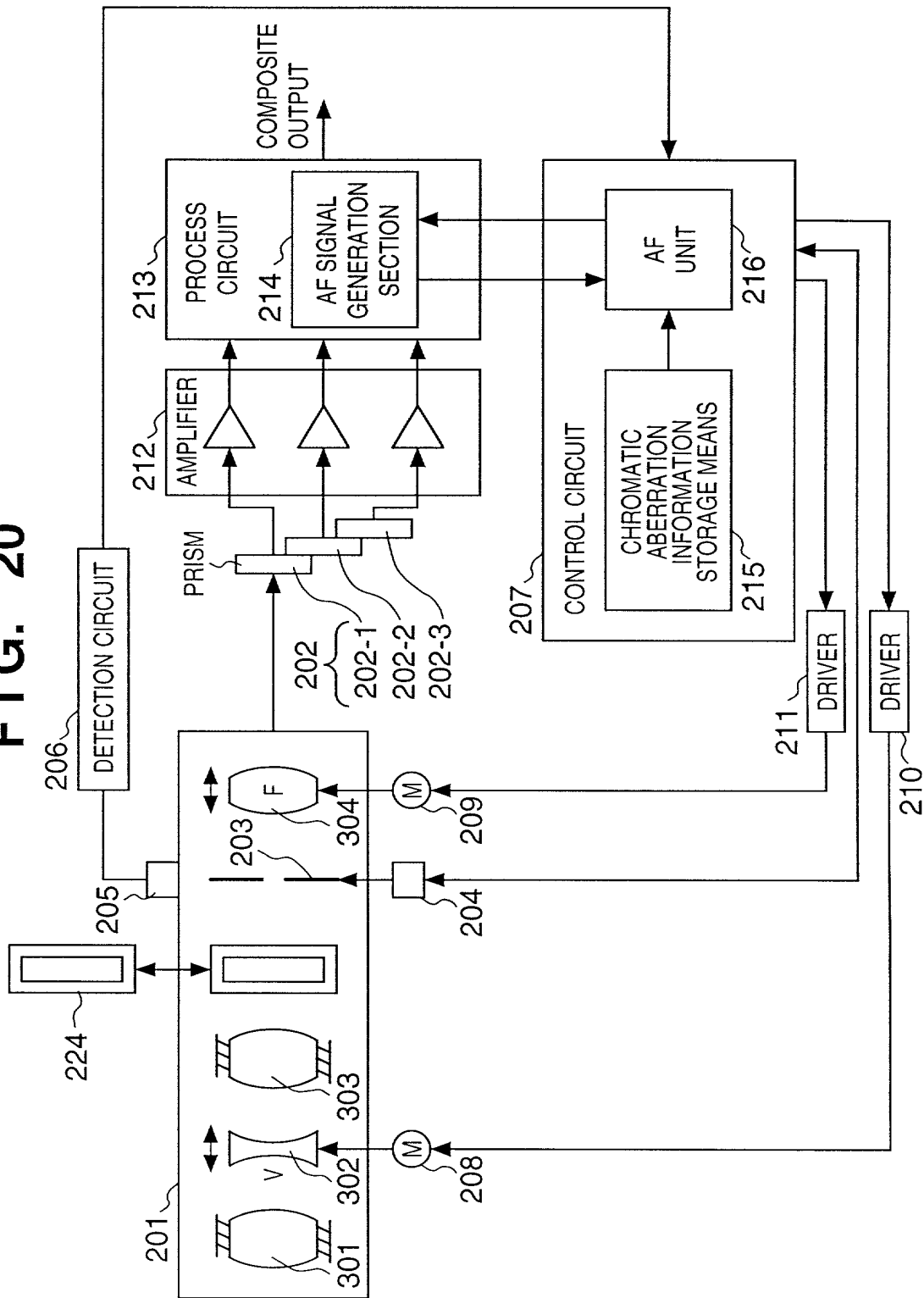


FIG. 21

